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POLISH GYNECOLOGY
GINEKOLOGIA POLSKA
ORGAN POLSKIEGO TOWARZYSTWA GINEKOLOGICZNEGO
THE OFFICIAL JOURNAL OF THE POLISH GYNECOLOGICAL SOCIETY

ISSN: 0017-0011

e-ISSN: 2543-6767

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DOI: 10.5603/gpl.92611

Article type: Research paper

Submitted: 2022-11-07

Accepted: 2024-07-11

Published online: 2024-10-11

ORIGINAL PAPER/OBSTETRICS

Factors associated with neonatal brachial palsy in shoulder dystocia: a longitudinal study

Neonatal brachial palsy after shoulder dystocia

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ABSTRACT

Objectives: The main goal is to analyze factors related to brachial plexus injury (BPI) after Shoulder Dystocia (SD).

Material and methods: Longitudinal prospective analysis of SD arose in a tertiary hospital from 1/1st/ 2019 to 12/31st/ 2020. A multivariable logistic regression for BPI after SD and a survival analysis for BPI recovery after SD were performed.

Results: In this period 13,414 deliveries were attended, 10,676 of those were vaginal deliveries (79.6%) reporting 69 cases of SD, with an incidence of 0.65%. SD required 102.1 seconds (SD) 10.8) as an average for solving it. Internal maneuvers were needed in 42.0% of SD reported. Neonatal BPI was suspected in 23 newborns (33.3%) at birth. Neonatal BPI at 48 hours of life was statistically associated with maternal BMI above 30 kg/m^2 (OR = 7.91; CI95% 1.3–47.7; p = 0.024), > 120 seconds for solving SD (OR = 14.4; CI95% 1.7–121.82; p = 0.014) and operative delivery (OR = 6.8; CI 95% 1.2–37.6; p = 0.028). The BPI recovery was statistically associated with clavicle fracture (HR = 0.31 CI95% 0.10–0.96 p = 0.042) and specific rehabilitation treatment (HR = 9.2 CI 95% 1.87–45.23 p = 0.006).

Conclusions: The following factors were associated with neonatal BPI at 48 hours of life: Maternal BMI above 30 kg/m^2, operative delivery, or shoulder dystocia that requires more than 120 seconds for solving it. The BPI recovery was associated with clavicle fracture and specific rehabilitation treatment.
Keywords: shoulder dystocia; brachial palsy; brachial plexus; dystocia

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INTRODUCTION

Shoulder dystocia (SD) is an obstetric emergency, with potentially devastating consequences, that occurs in 0.2–3% of all cephalic vaginal deliveries [1, 2]. Around two and a half percent of early perinatal mortality is caused by SD [3, 4]. In fact, SD is considered an “obstetric nightmare” [5]. Neonatal morbidity associated with SD is quite important, being brachial palsy the most prevalent injury. The brachial plexus injury (BPI) is the main lesion causing long-term disability, and it may appear up to 10% of all deliveries complicated with SD[4].

Certain maternal features such as gestational diabetes, obesity, fetal macrosomia, post-term pregnancy, and previous SD are associated with SD [6–10]. Other intrapartum characteristics such as excessively extended or rapid second stage of delivery [6, 10] or operative delivery[6] should also be taken into account. However, in general, risk factors associated with SD are yet poorly known, and its prediction is still challenging nowadays [1, 5]. For example, a few factors such as Diabetes Mellitus, neonatal weight above 4.000 g, or SD solving time above 120 seconds have been associated with BPI [11]. However, all predictive models evaluating SD, failed to properly foresee BPI associated with SD [11].

The main objective of this study is to analyze factors related to BPI after SD. The description of neonatal brachial palsy evolution is proposed as a secondary objective.

MATERIAL AND METHODS

This is a longitudinal prospective analysis of SD that arose in 'Virgen de la Arrixaca' University Hospital between 1st of January of 2019 and 31st of December of 2020. This study was approved by the Institutional Reviews Boards (2022-7-1-HCUVA). The principles of the Declaration of Helsinki were followed throughout the study. This center is the largest maternity department in Spain with above 7.500 births per year. In this period 13.414 deliveries were attended, 10676 of those were vaginal deliveries (79,6%).

A new SD notification system was introduced in January 2019, including the following information: the health professional who attends SD and their categories, the time at it occurs, the second stage duration, onset of labor, the time needed to solve SD, the maneuvers required, the need of episiotomy, head position, neonatal weight, APGAR score, cord blood gasometry, neonatal reanimation, and neonatal fracture. Third-trimester weight, height, and ultrasound parameters such as cephalic circumference (HC), abdominal circumference (AC), estimated fetal weight [12] were retrospectively recorded. Newborns were followed-up at 3, 6, and 12 months. When a BPI was suspected, a pediatric orthopedic evaluation before the discharge was required.

The diagnosis of neonatal brachial palsy was established based on clinical findings, which included arm weakness consistent with a brachial plexus injury. Electromyography was performed as needed to determine the localization and severity of nerve injury when neonatal brachial palsy persisted for more than 3 months after birth. All newborns were followed up by a pediatrician, infant orthopedic surgeon, or pediatric physiatrist. The strength in the upper limbs was assessed using the Medical Research Council (MRC) muscle strength testing scale, which classifies strength into five categories. When physical rehabilitation was required, the pediatric physiatrist provided intensive follow-up.

The primary outcome variable was neonatal brachial palsy at 48 hours of life. *A priori* statistical power of 48.49% was calc based on sample size. A descriptive analysis of all the variables analyzed was performed. Normality and homoscedasticity were assessed for all continuous variables with Shapiro-Wilk test and Levene test, respectively. All continuous variables respected the principles of normality and homoscedasticity. Proportions were compared using Pearson's chi-squared test and Fisher correction when applied. Obstetric history, anthropometric measurements, diabetes mellitus, cephalic circumference, abdominal circumference, AC/HC ratio, AC-HC difference, estimated fetal weight at 3rd trimester, the time needed to solve SD, and type of delivery underwent bivariate analysis using Student's t-test or Pearson's chi-squared test for to compare the characteristics of each group. Afterward, all variables above mentioned with p value < 0.2 in bivariate analysis were considered using a multivariate analysis logistic regression model. In common with all logistic regression analyses, this produced a model applicable to the dataset from which it was generated. A survival analysis of neonatal brachial palsy recovery was performed, and it was also adjusted by Cox regression. All tests were two-tailed, and the level of statistical significance was set at 0.05. Data analysis was performed using SPSS version 25.0 (SPSS Inc., Chicago, Illinois), RStudio version 1.2.5033: Integrated Development for R (RStudio, Inc., Boston, Massachusetts), R version 3.6.2 (https://www.r-project.org/. Accessed February 13, 2021) and STATA BE-Basic Edition version 17.0 (StataCorp, College Station, Texas).

RESULTS

A total of 69 SD was reported during the recruitment period. Of 13.414 deliveries that were attended, 2.738 were cesarean section (20.4%) and 10,676 vaginal deliveries (79.6%). The SD incidence was 0.65%. BPI at birth was suspected in 25 newborns (36.2%) whose birth was complicated with SD. However, this diagnosis was confirmed at 48 hours of life just in 14 babies (20.3%). These newborns were followed-up at 3, 6, and 12 months. Brachial palsy remained in five babies (7.2%) at 3 months, but only three babies (4.3%) suffered BPI finally (Image 1). Six newborns (24%) underwent conservative treatment with physiotherapy and specific rehabilitation treatment, and just one baby (4%) needed surgery. The specific rehabilitation treatment was prescribed by the pediatric physiatrist and includes passive range-of-motion exercises, supportive splints (to prevent finger flexion or elbow contractures), and the promotion of muscle strengthening.

The 26 pregnant women were nulliparous (37.7%), and just three (4.3%) had a previous cesarean section. 11.6% of the patients suffered from diabetes mellitus (DM). Pregestational diabetes was reported in five patients (7.2%) and three pregnancies (4.3%) resulted complicated with gestational diabetes mellitus. Regarding DM, 25.0% of them were managed with diet and exercise and 75.0% required insulin therapy. Two patients opted for insulin pump therapy.

The mean head circumference (HC) at 3rd trimester ultrasound scan was 326.6 mm (Standard Deviation 1.7). The mean abdominal circumference (AC) and the mean estimated fetal weight was 345.5 mm (Standard Deviation 3.3) and 3349.0 g (Standard Deviation 73.0) respectively. The mean difference AC-HC was 18.9 mm (Standard Deviation 2.8).

The labor onset as an average at 40.1 (Standard Deviation 0.2) gestation weeks. Delivery was attended by a midwife in 95.7% of the cases. Meanwhile, an obstetrician was present at delivery just in 66.7% of the births.

A right mediolateral episiotomy was required in 40 deliveries (58.0%). The obstetrics outcomes are shown in Table 1. Regarding operative deliveries, vacuum was required in 86.2%, Kjelland's forceps in 10.3%, and Thierry's Spatulas in 3.4%. The mean duration of the second stage of labor was 80.6 minutes (Standard Deviation 9.0). SD required 102.1 seconds (Standard Deviation 10.8) as an average for solving it.

The neonatal outcomes are resumed in Table 1. The mean pH in the artery and venous umbilical cord blood was 7.25 and 7.23 (Standard Deviation 0.0 and 0.1) respectively. The mean lactic acid concentration in umbilical cord blood was 5.49 mmol/L (Standard Deviation 0.7). The neonatal mean weight was 3988.3 grams (Standard Deviation 53.4). The mean HC at birth was 35.2 cm (Standard Deviation 0.2) and the mean height was 52.6 cm (Standard Deviation 0.2). Twelve babies (17.4%) required neonatal care unit (NCU) admission. Furthermore, other eight newborns (11.6%) were admitted to the neonatal intensive care unit (NICU).

SD was solved before 120 seconds in 57 cases (82.6%). Meanwhile, 29.8% of SD that required < 120 seconds (sec) experimented neonatal brachial palsy, 41.7% of SD that required >120 suffered from BPI. However, these differences increased at 48 hours of life when neonatal brachial palsy stilled in the 15.8% of SD that required < 120 sec, whereas palsy persisted in 41.7% of SD that required > 120 sec (p = 0.057).

The BPI at 48 hours of life incidence was statistically associated with the following variables in multivariant analysis: maternal BMI above 30 kg/m^2 (OR = 7.91; CI95% 1.31–47.69; p = 0.024), >120 seconds for solving SD (OR = 14.4; CI95% 1.7–121.82; p = 0.014) and operative delivery (OR = 6.79; CI95% 1.22–37.64; p = 0.028). No statistically significant association were found between neonatal brachial palsy at 48 hours of life and diabetes mellitus (OR = 2.36; CI95% 0.32–17.4; p = 0.399) nor ratio AC/HC > 1.1 (OR = 2.15; CI95% 0.24–19.36; p = 0.495).

When a BPI was confirmed, the recovery occurred with a median time of 3.4 days (CI95% 0.29-13.71). Kaplan-Meier curves for required time for solving shoulder dystocia are shown in Image 2. No statistically significant differences were found in BPI recovery at survival analysis for required time for solving shoulder dystocia (Log Rank p = 0.07). The BPI recovery was statistically associated with the following variables in multivariant Cox regression analysis (Table 2): Clavicle fracture (HR = 0.31 CI95% 0.10-0.96 p = 0.042) and specific rehabilitation treatment (HR = 9.2 CI95% 1.87–45.23 p = 0.006).

DISCUSSION

This study revealed the prevalence and evolution of brachial plexus injury in deliveries complicated with shoulder dystocia. Neonatal brachial palsy at 48 hours of life was statistically associated with maternal BMI above 30 kg/m^2, >120 seconds for solving SD and operative delivery. The BPI recovery was associated with specific rehabilitation treatment and clavicle fracture. A SD requiring more than 120 seconds for solving it was associated with the necessity of internal maneuvers, a score below 7 in the APGAR test at 5 and 10 minutes after birth and with NICU admission.

Previous publications associated an increasing number of maneuvers and also a larger amount of time for solving SD with more neonatal morbidity [13, 14]. Hoffman et al. [13] reported a brachial palsy rate of about 5% when just a maneuver is required. However, this rate increases up to 15% when four maneuvers are needed. Rotational maneuvers are associated with a higher risk of neonatal plexus injury[13]. Leung et al. found that 95% of SD requiring three or fewer maneuvers have a lower neonatal plexus injury rate than that SD requiring four or more maneuvers [15].

Primary (Mc Roberts and suprapubic pressure) and internal (Posterior arm and rotational maneuver) maneuvers were required in 100% and 42.0% respectively of SD reported in our study. Other authors reported a primary maneuvers success rate of 25.8% [15]. We hypothesized that not all SD, especially minor dystocia, are registered in the notification form system causing this difference.

This study has at least one year of follow-up. The neonatal brachial palsy evolution is similar to that reported by other authors [11, 16]. At birth and at 48 hours of life, the neonatal brachial palsy rate is high. Although, at 3–6 months most of the neonatal brachial palsy solved, from this point on, the recovery is more unlikely.

Neither AC at 3rd trimester ultrasound scan, HC, ratio AC/HC nor difference AC-HC are associated with neonatal brachial palsy. Other authors also revealed this difficult to predict neonatal brachial palsy with clinical or ultrasound parameters [17–20].

This logistic regression model for predicting BPI at 48 hours of life after SD is not robust. Other predicting models reported in the literature also fail to predict neonatal brachial palsy [11, 14, 16]. In our regression model, neonatal brachial palsy at 48 hours of life is statistically associated with maternal BMI >30 kg/m^2, >120 seconds for solving SD and operative delivery. The most important factor seems to be time for solving SD, as other authors reported [14, 15]. Although maternal BMI was previously analyzed as a relevant factor for BPI after SD [14, 20], this is the first time that maternal BMI is statistically associated with neonatal BPI after SD. Therefore, obesity primary prevention during pregnancy could be crucial in preventing neonatal morbidity associated with BPI after SD.

The rate of neonatal BPI spontaneous recovery ranges between 75 and 90% [21]. In our study, a spontaneous recovery occurred in 80% of neonatal BPI (25/5) during the first three months. The short BPI recovery median time showed that the majority of BPI solved spontaneously during the first three months of life. Certain factors were associated with a BPI recovery such as clavicle fracture (HR = 0.31) and specific rehabilitation treatment (HR = 9.2). Other authors reported the operative delivery and newborn weight > 4000 grams as factors associated with neonatal BPI persistency [22, 23]. Wilson et al. reported no association between clavicle or humerus fracture and neonatal BPI recovery. To the best of our knowledge, no report performing a survival analysis of neonatal BPI after SD has been published. This is the first time that clavicle fracture and specific rehabilitation treatment are associated with neonatal BPI recovery. We hypothesized that a greater force would be applied in those SD with clavicle fracture, causing severe nerve injuries that might hinder BPI recovery.

Some strengths should be highlighted. A logistic regression model for neonatal BPI after SD and a Cox regression model for neonatal BPI recovery were performed. The health care professional team that attends all deliveries in the hospital did not suffer any modification during this period. Thanks to many deliveries attended in the center, there is a relevant incidence of SD. Furthermore, it should be emphasized that an obstetrics emergency simulation-based program involving hospital attendants, nursing assistants, midwives, residents, anesthesiologists, pediatricians, and obstetricians was implemented in 2019.

An important limitation of our study is that the SD notification system is based on a self-filling paper form. Because of this, some fields are free text variables. It would be desirable a prospective multicentric analysis that includes more cases making stats analysis more robust. The medical records were not equally detailed in all the cases (i.e. upper and lower brachial plexus injury), what makes impossible to compare these characteristics.

In conclusion, shoulder dystocia is an obstetric emergency. Neonatal brachial palsy is a characteristic consequence of shoulder dystocia. Certain factors such as maternal BMI above 30 kg/m^2, operative delivery, or shoulder dystocia that requires more than 120 seconds for solving it are associated with neonatal brachial palsy at 48 hours of life. The BPI recovery was associated with specific rehabilitation treatment and clavicle fracture.

Article information and declarations

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author contributions

All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest

The authors declare no conflict of interest.

Informed consent

Not applicable.

Ethics statement

The local Institutional Review Board deemed the study exempt from review.

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Figure 1. Neonatal brachial palsy evolution compared by the duration of shoulder dystocia

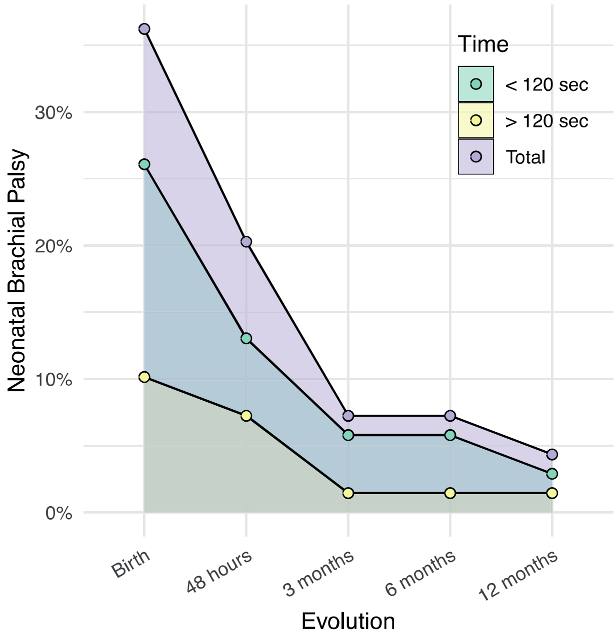

Figure 2. Neonatal brachial palsy recovery: Kaplan-Meier curves for required time for solving shoulder dystocia

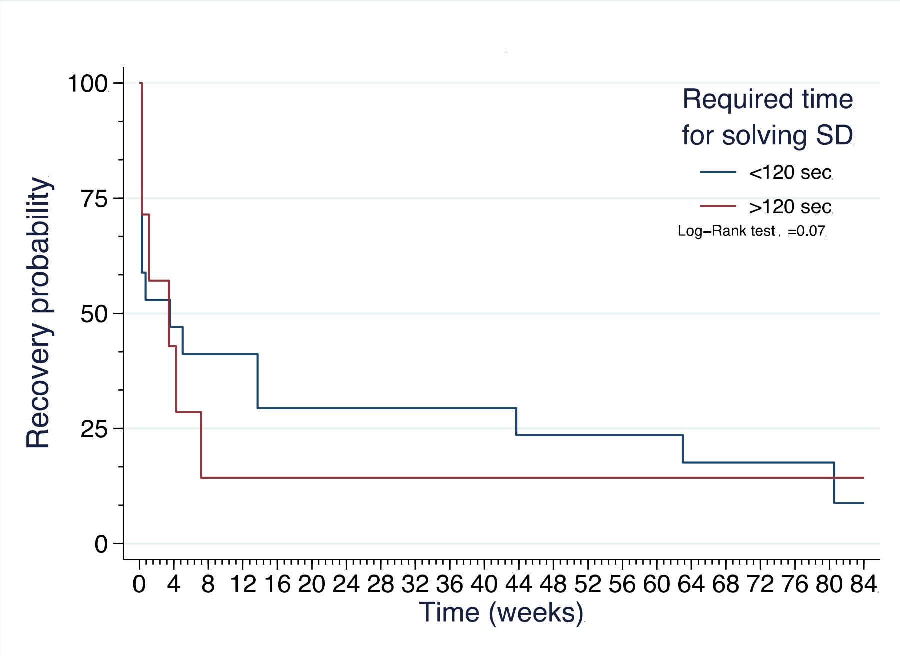

Table 1. Obstetrics outcomes compared by the duration of shoulder dystocia; BMI — Body Mass Index

		Shoulder dystocia duration				
		< 120 seg (n = 57)		> 120 seg (n = 12)		p value
		n	Relative frequency	n	Relative frequency	
Age	< 20 years	2	3.5%	1	8.3%	0.392
	20-35 years	35	61.4%	9	75.0%	
	≥ 35 years	20	35.1%	2	16.7%	
Primary maneuvers		57	100%	12	100%	
Mc Roberts		57	100%	12	100%	
Suprapubic pressure		49	86%	12	100%	0.334
Posterior arm		21	36.8%	8	66.7%	0.057
Rotational maneuvers		6	10.5%	4	33.3%	**0.041**
Clavicle fracture		7	12.3%	4	33.3%	0.090
BMI	BMI < 30 kg/m^2	23	40.4%	7	58.3%	0.253
	BMI > 30 kg/m^2	34	59.6%	5	41.7%	
Diabetes Mellitus		5	8.8%	3	25%	0.137
Labor onset	Spontaneous	29	50.9%	7	58.3%	0.638
	Induced	28	49.1%	5	41.7%	
Delivery	Spontaneous	33	57.9%	8	66.7%	0.749
	Operative	24	42.1%	4	33.3%	

Episiotomy	32	56.1%	8	66.7%	0.502
APGAR at birth ≤ 6	7	12.3%	4	33.3%	0.070
APGAR at 5 minutes ≤ 6	1	1.8%	3	25%	**0.002**
APGAR at 10 minutes ≤ 6	0	0%	2	16.7%	**0.002**
Neonatal care unit admission	7	12.3%	5	41.7%	**0.015**
NICU admission	4	7.0%	4	33.3%	**0.010**

Table 2. Multivariate Cox regression analysis of neonatal brachial palsy recovery

Variable	HR	CI95%	p value
Newborn weight > 4000 g	1.01	0.38-2.71	0.979
Operative delivery	0.51	0.17-1.51	0.221
Posterior arm maneuvers	2.62	0.80-8.62	0.113
Rotational maneuvers	0.70	0.20-2.38	0.564
Clavicle fracture	0.31	0.10-0.96	**0.042**
Specific rehabilitation treatment	9.2	1.87-45.23	**0.006**
Surgery	6.58	0.44-99.51	0.174